

WHAT IS CLAIMED IS:

1. A method of synchronizing individual engine cylinder fuel changes to their respective changes in exhaust gases, including the steps of:
 - correlating controlled fuel changes between individual injectors to subsequent detected exhaust A/F ratio changes greater than during normal operation; and
 - storing in memory a time delay period based upon a time difference between causing the fuel change and the detected exhaust A/F ratio changes.
2. A method according to claim 1, further comprising the step of:
 - determining an oxygen sensor time response characteristics for assessing proper operating condition of the oxygen sensor using the time delay period stored in memory.
3. A method of individual engine cylinder closed loop fuel control, including the steps of:
 - detecting exhaust gases' conditions with a switching oxygen sensor;
 - detecting at least one engine parameter sufficient to determine stable engine operational conditions during;
 - sampling the switching oxygen sensor output during a first period, at a time determined by the initial presence of a selected individual cylinder's exhaust gases;
 - causing a minimum change in fuel quantity into selected individual cylinder sufficient to produce a change in the switching oxygen sensor output, from the selected individual cylinder's exhaust gases' conditions sampled in the first time period, during a second period;

comparing the minimum change in fuel quantity causing the change in the switching oxygen sensor output for the selected individual cylinder to associated minimums of all other individual cylinders during stoichiometric conditions; and establishing a fuel quantity offset for each individual cylinder by adjusting all cylinders' offsets such that at least one cylinder has a zero offset.

4. A method of synchronizing individual engine cylinder fuel changes to resulting changes in exhaust gases, including the steps of:

detecting exhaust gases' conditions with an oxygen sensor;
detecting at least one engine parameter sufficient to determine stable exhaust gases' conditions for monitoring during a first time period;
causing a sequence of changes in fuel quantity to at least one selected grouping of cylinders, during a second time period, differing from the fuel quantity in said first time period, so as to produce a change in exhaust gases' A/F conditions differing from the exhaust gases' conditions detected during the first time period;
monitor a time period, from a selected reference point, for the time of the first change in said A/F conditions that are caused by said changes in fuel quantity during said second time period; and
storing in memory the monitored time period from the selected reference point.

5. A method according to claim 4, whereby the oxygen sensor detecting exhaust gases' conditions is a switching type sensor having two discrete output voltage characteristics for conditions richer and leaner than stoichiometric.

6. A method of transient fuel compensation, including the steps of:
 - detecting, during a first time period, transient engine load condition changes that may subsequently cause exhaust gases' air-fuel ratio to deviate from a defined control point;
 - causing a change in fuel quantities to one or more selected individual engine cylinders, differing from quantities in the first time period, during a second time period for adjusting for the effects of the transient engine load condition changes;
 - measuring effects of the one or more selected individual engine cylinders' exhaust gases' conditions resulting from the changes in fuel quantities, by sampling during predetermined time periods, during said second time period; and
 - making modifications in fuel quantities supplied to another selection of one or more selected individual cylinders, after measuring the one or more individual cylinders' exhaust gases' conditions that result from the prior changes in fuel quantities to the one or more selected individual cylinders, so as to cause air-fuel ratio fluctuations about the defined control point.

7. A method of individual cylinder fuel control compensating for transient engine load changes, including the steps of:
 - monitoring engine exhaust gases with an oxygen sensor;
 - detecting conditions indicating a load change and enabling individual cylinder fuel control;

enabling a change in fuel quantity to at least one selected individual cylinder, to produce a change in exhaust gases' A/F conditions that adjusts for effects of the load change;

detecting exhaust gases' conditions resulting from each individual cylinders' said change in fuel quantity by sampling at predetermined times; and

controlling subsequent changes in cylinder's fuel quantity, such changes depending on effects that each previous said change in fuel quantities has on subsequent exhaust gases' A/F conditions detected for each individual cylinders' combustion event, to cause cycling of gases' A/F about a defined control point and compensate exhaust gases' A/F conditions for said load changes.

8. A method according to claim 7, whereby the change in fuel quantity is implemented gradually by transitioning the controlled fuel changes into individual cylinders over a number of cylinder firing events in order to minimize perceived changes in engine smoothness caused by step changes in engine cylinders' torque levels.

9. A method according to claim 7, whereby said causing cycling of gases' A/F about a defined control point is used to determine dynamic catalyst oxygen storage characteristics during non-stoichiometric conditions for modifying subsequent fuel changes into the individual cylinders for more quickly reaching the defined control point.

10. A method according to claim 7, wherein the changes in fuel quantity are determined using stored correction values based upon oxygen sensor feedback during

prior engine load changes of similar characteristics, such said feedback from subsequent prior combustion events having said fuel quantity causing said cycling of gases' A/F about a defined control point.

11. A method according to claim 7, whereby said oxygen sensor is a wide range linear type device allowing more rapid correction of measured exhaust gases' A/F ratio deviations from defined control points.

12. A method of compensating for transient engine load changes, including the steps of:

providing selected individual cylinder injection probe events, after a predefined number of normal fuel injection events, to have corrections in magnitudes of fuel quantity to counteract effects of load changes; and

adjusting the corrections in magnitudes of fuel quantity to selected individual cylinders, based upon oxygen sensor feedback of exhaust gases' conditions resulting from prior said probe events by said sensor sampling at predetermined times so as to cause the exhaust gases' conditions to cycle about a defined control point at an earlier time following the load change.

13. A method of early cycling an oxygen sensor's output, during non-stoichiometric transient engine load change conditions, including the steps of:

causing estimated fuel changes into selected individual cylinders; and

modifying subsequently said estimated fuel changes using a successive approximation approach based upon feedback determined by sampling the oxygen sensor's output during predetermined time periods.

14. A method of individual cylinder fuel control compensating for transient engine load changes, including the steps of:

providing a device for electrically controlling engine airflow based upon operator power demands;

detecting at least one parameter indicating future power demands causing engine operation outside a defined control range based upon an imminent engine load change;

delaying change in the device for electrically controlling engine airflow due to said future power demands until first delivering estimated fuel quantities into individual cylinders that compensates for said imminent load change; and

activating change in the device for electrically controlling engine airflow so as to meet said imminent engine load change requirements.

15. A method according to claim 14, wherein said estimated fuel quantities into individual cylinders are modified by stored correction values, based upon fuel quantities used during prior imminent engine load change events of similar characteristics, said stored correction values providing compensation during prior load changes based upon feedback from exhaust gases' conditions.

16. A method of rapid correction of A/F ratio deviations from a defined control point following an engine load change, including the step of:

controlling fuel quantities, for selected individual cylinders, based upon monitoring exhaust gases' A/F conditions at predetermined times, in order to determine necessary fuel quantity corrections for subsequent selected individual cylinders' combustion events that will result in cycling of catalyst inlet gases' A/F about a defined control point.

17. A method for reducing levels of engine vibration perceptible to a vehicle's occupants, including the step of:

controlling frequency characteristics of engine torque fluctuations caused by engine control changes, said frequency characteristics controlled to minimize excitation of vehicle resonance points.

18. A method according to claim 17, whereby said levels of engine vibration perceptible to a vehicle's occupants are reduced by adjusting the magnitude of engine fuel control changes versus time so as to minimize various vehicle components' resonance excitation characteristics.

19. A method of providing excess oxygen into catalytic converter inlet gases', including the steps of:

providing an electronic valve control system; and

controlling with the electronic valve system both an intake valve and an exhaust valve of an engine to be opened simultaneously when pressure conditions in an intake manifold exceed those in an exhaust manifold of the engine.

20. A method according to 19, whereby said providing excess oxygen into the inlet gases of a catalytic converter is used to produce catalyst heating by causing at least one engine cylinder's exhaust gases to be controlled richer than stoichiometric conditions.

21. A method of synchronizing individual engine cylinder fuel changes to subsequent changes in exhaust gases' air/fuel conditions including:

detecting exhaust gases' conditions with a switching oxygen sensor;
detecting at least one engine parameter sufficient to determine stable exhaust gases' conditions for monitoring;
determining oxygen sensor conditions during a first time period;
causing a sequence of at least a first change in fuel quantity to at least one selected grouping of engine cylinders, said first change in quantity differing from a quantity present in said first time period, so as to produce at least one transition in oxygen sensor output conditions differing from said conditions detected during said first time period;

monitoring a time period from determining the time of a first transition in said oxygen sensor conditions that are caused by said changes in fuel quantity during said second time period; and

storing in memory said monitored time period.

22. A method according to claim 21, whereby additional recordings of said measured time are measured by causing a sequence of said transitions in oxygen sensor output conditions so as to determine a more accurate average for a value of said time period that can be stored in memory.

23. A method of identifying an individual cylinders' oxygen sensor's response time, when an individual engine cylinders' fuel changes cause subsequent changes in exhaust gases' conditions, including the steps of:

causing a sequence of at least two transitions in said oxygen sensor's output conditions by enabling controlled changes in fuel quantity to at least one selected grouping of cylinders; and

measuring a time difference between the first individual cylinder having the second enabling controlled change in fuel quantity and a time of a second transition in oxygen sensor output conditions.

24. A method of individual cylinder fuel control, including the steps of:

compensating for transient engine load changes by delivering estimated fuel quantities into selected individual cylinders; and

modifying said estimated fuel quantities by monitoring subsequent exhaust gases' A/F conditions detected for the selected individual cylinders' combustion event at

predetermined times, until said exhaust gases' A/F conditions fluctuate about a defined control point.